DiscoMatch: Fast Discrete Optimisation for Geometrically Consistent 3D Shape Matching

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CODE

Shape matching approaches

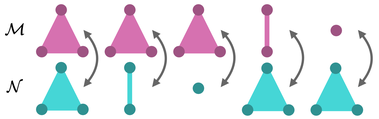
	Neural nets	Discrete optimization	Ours
Fast inference	✓	✗	(✓)
Satisfy structural constraints	✗	✓	✓
Learn from examples	✓	✗	✓

Geometrically consistent shape matching

- Integer linear program (ILP) formulation of [3]

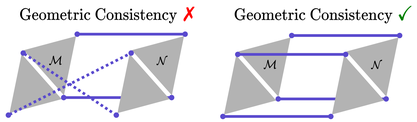
$$\min_{x \in \{0,1\}^{|P|}} c^\top x \quad \text{s.t.} \quad \begin{bmatrix} A^\partial \\ A^{\mathcal{M}} \\ A^{\mathcal{N}} \end{bmatrix} x = \begin{bmatrix} 0 \\ 1 \\ 1 \end{bmatrix} \qquad \text{(P)}$$

- Matching elements: all possible $\triangle \leftrightarrow \triangle$, $\triangle \leftrightarrow |$ and $\triangle \leftrightarrow \cdot$ correspondences (i-th element encoded by binary variable x_i with matching cost c_i)

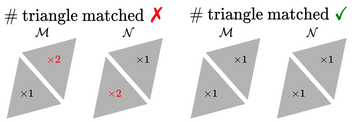


- Constraints

A^∂: geometric consistency constraints



$A^{\mathcal{M}}, A^{\mathcal{N}}$: projection constraints



Fast ILP solver on GPU

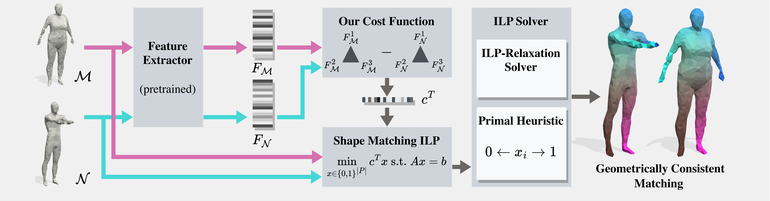
Learned matching costs

Compute matching costs between triangles of $\mathcal{M}$ and $\mathcal{N}$ as

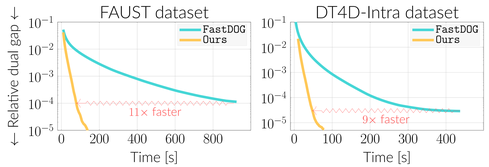
$$\sum_{v=1}^{3} (A^{\mathcal{M}}_{m_v} + A^{\mathcal{N}}_{n_v}) \left\| F^{\mathcal{M}}_{m_v} - F^{\mathcal{N}}_{n_v} \right\| .$$

(m_1, m_2, m_3): triangle m in $\mathcal{M}$, F_u: Features [2] of vertex u, A_u: Area around vertex u

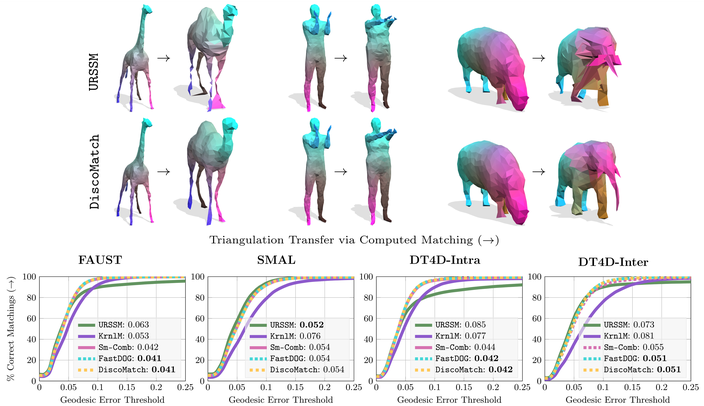
Pipeline



ILP solver comparison

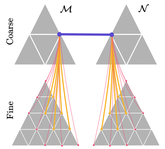


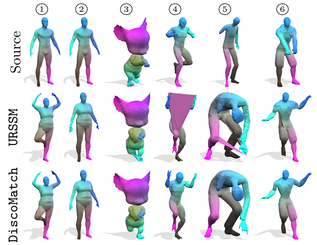
Shape matching comparison



Scaling to higher resolutions

Propagate solutions from coarser res. to prune finer res.





[1] Ahmed Abbas and Paul Swoboda. FastDOG: Fast discrete optimization on GPU. In *CVPR*, 2022.

[2] Dongliang Cao, Paul Roetzer, and Florian Bernard. Unsupervised learning of robust spectral shape matching. *ACM Trans. Graph.*, 2023.

[3] Thomas Windheuser, Ulrich Schlickewei, Frank R Schmidt, and Daniel Cremers. Geometrically consistent elastic matching of 3d shapes: A linear programming solution. In *ICCV*, 2011.

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